Bonfiglioli
Vectron

Agile

Modbus/TCP
Communication module CM-Modbus/TCP
Frequency inverter 230 V / 400 V

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power, control and green solutions

1 General Information about the Documentation

For better clarity, the documentation of the frequency inverter is structured according to the customer-specific requirements.

The present manual was created in the German language. The German manual is the original version. Other language versions are translations.

Quick Start Guide

The “Quick Start Guide” describes the basic steps required for mechanical and electrical installation of the frequency inverter. The guided commissioning supports you in the selection of necessary parameters and the configuration of the software of the frequency inverter.

User manual

The user manual documents the complete functionality of the frequency inverter. The parameters required for special purposes, for adjustment to the application and the numerous additional functions are described in detail.

Separate user manuals are supplied for optional components for the frequency inverter. These manuals complement the operating instructions and the “Quick Start Guide” for the frequency inverter.

Application manual

The application manual complements the documentation to ensure goal-directed installation and commissioning of the frequency inverter. Information on various topics in connection with the use of the frequency inverter is described in context with the specific application.

1.1 This document

This document describes the communication via the Modbus/TCP protocol with frequency inverters of the *Agile* series of devices. Thanks to the modular hardware and software structure, the frequency inverters can be customized to meet to customer's specific requirements, including applications requiring high functionality and dynamism.

⚠ WARNING

Compliance with the documentation is required to ensure safe operation of the frequency inverter. BONFIGLIOLI VECTRON GmbH shall not be held liable for any damage caused by any non-compliance with the documentation.

In case any problems occur which are not covered by the documentation sufficiently, please contact the manufacturer.

1.2 Warranty and liability

BONFIGLIOLI VECTRON GmbH would like to point out that the contents of this user manual do not form part of any previous or existing agreement, assurance or legal relationship. Neither are they intended to supplement or replace such agreements, assurances or legal relationships. Any obligations of the manufacturer shall solely be based on the relevant purchase agreement which also includes the complete and solely valid warranty stipulations. These contractual warranty provisions are neither extended nor limited by the specifications contained in this documentation.

The manufacturer reserves the right to correct or amend the specifications, product information and omissions in these operating instructions without notice. The manufacturer shall not be liable for any damage, injuries or costs which may be caused for the aforementioned reasons.

Furthermore, BONFIGLIOLI VECTRON GmbH excludes any warranty/liability claims for any personal and/or material damage if such damage is due to one or more of the following causes:

- inappropriate use of the frequency inverter,
- non-compliance with the instructions, warnings and prohibitions contained in the documentation,
- unauthorized modifications of the frequency inverter,
- insufficient monitoring of parts of the machine/plant which are subject to wear,
- repair work at the machine/plant not carried out properly or in time,
- catastrophes by external impact and force majeure.

1.3 Obligation

This user manual must be read before commissioning and complied with. Anybody entrusted with tasks in connection with the

- transport,
- assembly,
- installation of the frequency inverter and
- operation of the frequency inverter

must have read and understood the user manual and, in particular, the safety instructions in order to prevent personal and material losses.

1.4 Copyright

In accordance with applicable law against unfair competition, this user manual is a certificate. Any copyrights relating to it shall remain with

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This user manual is intended for the operator of the frequency inverter. Any disclosure or copying of this document, exploitation and communication of its contents (as hardcopy or electronically) shall be forbidden, unless permitted expressly.

Any non-compliance will constitute an offense against the copyright law dated 09 September 1965, the law against unfair competition and the Civil Code and may result in claims for damages. All rights relating to patent, utility model or design registration reserved.

1.5 Storage

The documentation form an integral part of the frequency inverter. It must be stored such that it is accessible to operating staff at all times. If the frequency inverter is sold on to other users, then this user manual must also be handed over.

2 General safety instructions and information on use

The chapter "General safety instructions and information on use" contains general safety instructions for the Operator and the Operating Staff. At the beginning of certain main chapters, some safety instructions are included which apply to all work described in the relevant chapter. Special work-specific safety instructions are provided before each safety-relevant work step.

2.1 Terminology

According to the documentation, different activities must be performed by certain persons with certain qualifications.

The groups of persons with the required qualification are defined as follows:

Operator

This is the entrepreneur/company who/which operates the frequency inverter and uses it as per the specifications or has it operated by qualified and instructed staff.

Operating staff

The term Operating Staff covers persons instructed by the Operator of the frequency inverter and assigned the task of operating the frequency inverter.

Skilled Personnel

The term **Skilled Personnel** covers staff that are assigned special tasks by the Operator of the frequency inverter, e.g. installation, maintenance and service/repair and troubleshooting. Based on their qualification and/or know-how, **Skilled Personnel** must be capable of identifying defects and assessing functions.

Qualified electrician

The term Qualified Electrician covers qualified and trained staff that have special technical know-how and experience with electrical installations. In addition, Qualified Electricians must be familiar with the applicable standards and regulations, they must be able to assess the assigned tasks properly and identify and eliminate potential hazards.

Instructed person

The term Instructed Person covers staff that are instructed and trained about/in the assigned tasks and the potential hazards that might result from inappropriate behavior. In addition, instructed persons must have been instructed in the required protection provisions, protective measures, the applicable directives, accident prevention regulations as well as the operating conditions and have their qualification verified.

Expert

The term Expert covers qualified and trained staff that have special technical know-how and experience relating to the frequency inverter. Experts must be familiar with the applicable government work safety directives, accident prevention regulations, guidelines and generally accepted rules of technology in order to assess the operationally safe condition of the frequency inverter.

2.2 Designated use

The frequency inverter is designed according to the state of the art and recognized safety regulations.

The frequency inverters are electrical drive components intended for installation in industrial plants or machines. Commissioning and start of operation is not allowed until it has been verified that the machine meets the requirements of the EC Machinery Directive 2006/42/EC and DIN EN 60204-1.

The frequency inverters meet the requirements of the low voltage directive 2006/95/EEC and DIN EN 61800-5-1. CE-labeling is based on these standards. Responsibility for compliance with the EMC Directive 2004/108/EC lies with the operator. Frequency inverters are only available at specialized dealers and are exclusively intended for commercial use as per EN 61000-3-2.

No capacitive loads may be connected to the frequency inverter.

The technical data, connection specifications and information on ambient conditions are indicated on the rating plate and in the documentation and must be complied with at all times.

2.3 Misuse

Any use other than that described in "Designated use" shall not be permissible and shall be considered as misuse.

For, example, the machine/plant must not be operated

- by uninstructed staff,
- while it is not in perfect condition,
- without protection enclosure (e.g. covers),
- without safety equipment or with safety equipment deactivated.

The manufacturer shall not be held liable for any damage resulting from such misuse. The plant operator shall bear the sole risk.

2.3.1 Explosion protection

The frequency inverter is an IP 20 protection class device. For this reason, use of the device in explosive atmospheres is not permitted.

2.4 Residual risks

Residual risks are special hazards involved in handling of the frequency inverter which cannot be eliminated despite the safety-compliant design of the device. Remaining hazards are not obvious and can be a source of possible injury or health damage.

Typical residual hazards include:

Electrical hazard

Danger of contact with energized components due to a defect, opened covers or enclosures or improper working on electrical equipment.

Danger of contact with energized components in frequency inverter if no external disconnection device was installed by the operator.

Electrostatic charging

Touching electronic components bears the risk of electrostatic discharges.

Thermal hazards

Risk of accidents by hot machine/plant surfaces, e.g. heat sink, transformer, fuse or sine filter.

Charged capacitors in DC link

The DC link may have dangerous voltage levels even up to three minutes after shutdown.

Danger of equipment falling down/over, e.g. during transport

Center of gravity is not the middle of the electric cabinet modules.

2.5 Safety and warning signs at frequency inverter

- Comply with all safety instructions and danger information provided on the frequency inverter.
- Safety information and warnings on the frequency inverter must not be removed.

2.6 Warning information and symbols used in the user manual

2.6.1 Hazard classes

The following hazard identifications and symbols are used to mark particularly important information:

⚠ DANGER

Identification of immediate threat holding a **high** risk of death or serious injury if not avoided.

⚠ WARNING

Identification of immediate threat holding a **medium** risk of death or serious injury if not avoided.

⚠ CAUTION

Identification of immediate threat holding a **low** risk of minor or moderate physical injury if not avoided.

NOTE

Identification of a threat holding a risk of material damage if not avoided.

2.6.2 Hazard symbols

Symbol	Meaning	Symbol	Meaning
	General hazard		Suspended load
	Electrical voltage		Hot surfaces

2.6.3 Prohibition signs

Symbol	Meaning
	No switching; it is forbidden to switch the machine/plant, assembly on

2.6.4 Personal safety equipment

Symbol	Meaning
	Wear body protection

2.6.5 Recycling

Symbol	Meaning
	Recycling, to avoid waste, collect all materials for reuse

2.6.6 Grounding symbol

Symbol	Meaning
	Ground connection

2.6.7 ESD symbol

Symbol	Meaning
	ESD: Electrostatic Discharge (can damage components and assemblies)

2.6.8 Information signs

Symbol	Meaning
	Tips and information making using the frequency inverter easier.

2.6.9 Font style in documentation

Example	Font style	Use
1234	bold	Representation of parameter numbers
Parameter	italic, Font Times New Roman	Representation of parameter names
P.1234	bold	Representation of parameter numbers without name, e.g. in formulas
Q.1234	bold	Representation of source numbers

2.7 Directives and guidelines to be adhered to by the operator

The operator must follow the following directives and regulations:

- Ensure that the applicable workplace-related accident prevention regulations as well as other applicable national regulation are accessible to the staff.
- An authorized person must ensure, before using the frequency inverter, that the device is used in compliance with its designated use and that all safety requirements are met.
- Additionally, comply with the applicable laws, regulations and directives of the country in which the frequency inverter is used.

Any additional guidelines and directives that may be required additionally shall be defined by the operator of the machine/plant considering the operating environment.

2.8 Operator's general plant documentation

- In addition to the user manual, the operator should issue separate internal operating instructions for the frequency inverter. The user manual of the frequency inverter must be included in the user manual of the whole plant.

2.9 Operator's / operating staff's responsibilities

2.9.1 Selection and qualification of staff

- Any work on the frequency inverter may only be carried out by qualified technical staff. The staff must not be under the influence of any drugs. Note the minimum age required by law. Define the staff's responsibility in connection with all work on the frequency inverter clearly.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering.
- The operating staff must be trained for the relevant work to be performed.

2.9.2 General work safety

- In addition to the user manual of the machine/plant, any applicable legal or other regulations relating to accident prevention and environmental protection must be complied with. The staff must be instructed accordingly.
  Such regulations and/or requirements may include, for example, handling of hazardous media and materials or provision/use of personal protective equipment.
- In addition to this user manual, issue any additional directives that may be required to meet specific operating requirements, including supervision and reporting requirements, e.g. directives relating to work organization, workflow and employed staff.
- Unless approved of expressly by the manufacturer, do not modify the frequency inverter in any way, including addition of attachments or retrofits.
- Only use the frequency inverter if the rated connection and setup values specified by the manufacturer are met.
- Provide appropriate tools as may be required for performing all work on the frequency inverter properly.

2.10 Organizational measures

2.10.1 General

- Train your staff in the handling and use of the frequency inverter and the machine/plant as well as the risks involved.
- Use of any individual parts or components of the frequency inverter in other parts of the operator's machine/plant is prohibited.
- Optional components for the frequency inverter must be used in accordance with their designated use and in compliance with the relevant documentation.

2.10.2 Use in combination with third-party products

- Please note that BONFIGLIOLI VECTRON GmbH will not accept any responsibility for compatibility with third-party products (e.g. motors, cables or filters).
- In order to enable optimum system compatibility, BONFIGLIOLI VECTRON GmbH offers components facilitating commissioning and providing optimum synchronization of the machine/plant parts in operation.
- If you use the frequency inverter in combination with third-party products, you do this at your own risk.

2.10.3 Transport and Storage

- The frequency inverters must be transported and stored in an appropriate way. During transport and storage the devices must remain in their original packaging.
- The units may only be stored in dry rooms which are protected against dust and moisture and are exposed to small temperature deviations only. The requirements of DIN EN 60721-3-1 for storage, DIN EN 60721-3-2 for transport and labeling on the packaging must be met.
- The duration of storage without connection to the permissible nominal voltage may not exceed one year.

2.10.4 Handling and installation

- Do not commission any damaged or destroyed components.
- Prevent any mechanical overloading of the frequency inverter. Do not bend any components and never change the isolation distances.
- Do not touch any electronic construction elements and contacts. The frequency inverter is equipped with components which are sensitive to electrostatic energy and can be damaged if handled improperly. Any use of damaged or destroyed components will endanger the machine/plant safety and shall be considered as a non-compliance with the applicable standards.
- Only install the frequency inverter in a suitable operating environment. The frequency inverter is exclusively designed for installation in industrial environments.
- If seals are removed from the case, this can result in the warranty becoming null and void.

2.10.5 Electrical connections

- The five safety rules must be complied with.
- Never touch live terminals. The DC link may have dangerous voltage levels even up to three minutes after shutdown.
- When performing any work on/with the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants of the country in which the frequency inverter is used.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.
- Only connect the frequency inverter to suitable supply mains.

2.10.5.1 The five safety rules

When working on/in electrical plants, always follow the five safety rules:

1. Isolate
2. Take appropriate measures to prevent re-connection
3. Check isolation
4. Earth and short-circuit
5. Cover or shield neighboring live parts.

2.10.6 Safe operation

- During operation of the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to the applicable national and international safety directives.
- During operation, never open the machine/plant
- Do not connect/disconnect any components/equipment during operation.
- The machine/plant holds high voltage levels during operation, is equipped with rotating parts (fan) and has hot surfaces. Any unauthorized removal of covers, improper use, wrong installation or operation may result in serious injuries or material damage.

- Some components, e.g. the heat sink or brake resistor, may be hot even some time after the machine/plant was shut down. Don't touch any surfaces directly after shutdown. Wear safety gloves where necessary.
- The frequency inverter may hold dangerous voltage levels until the capacitor in the DC link is discharged. Wait for at least 3 minutes after shutdown before starting electrical or mechanical work on the frequency inverter. Even after this waiting time, make sure that the equipment is deenergized in accordance with the safety rules before starting the work.
- In order to avoid accidents or damage, only qualified staff and electricians may carry out the work such as installation, commissioning or setup.
- In the case of a defect of terminals and/or cables, immediately disconnect the frequency inverter from mains supply.
- Persons not familiar with the operation of frequency inverters must not have access to the frequency inverter. Do not bypass nor decommission any protective facilities.
- The frequency inverter may be connected to power supply every 60 s. This must be considered when operating a mains contactor in jog operation mode. For commissioning or after an emergency stop, a non-recurrent, direct restart is permissible.
- After a failure and restoration of the power supply, the motor may start unexpectedly if the Auto-Start function is activated.
  If staff are endangered, a restart of the motor must be prevented by means of external circuitry.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to EN 60204 and applicable safety directives (e.g. Working Machines Act or Accident Prevention Directives).

2.10.7 Maintenance and service / troubleshooting

- Visually inspect the frequency inverter when carrying out the required maintenance work and inspections at the machine/plant.
- Perform the maintenance work and inspections prescribed for the machine carefully, including the specifications on parts/equipment replacement.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering. Only use original spare parts.
- Unauthorized opening and improper interventions in the machine/plant can lead to personal injury or material damage. Repairs on the frequency inverters may only be carried out by the manufacturer or persons authorized by the manufacturer. Check protective equipment regularly.
- Before performing any maintenance work, the machine/plant must be disconnected from mains supply and secured against restarting. The five safety rules must be complied with.

2.10.8 Final decommissioning

Unless separate return or disposal agreements were made, recycle the disassembled frequency inverter components:

- Scrap metal materials
- Recycle plastic elements
- Sort and dispose of other component materials

Electric scrap, electronic components, lubricants and other utility materials must be treated as special waste and may only be disposed of by specialized companies.

Always comply with any applicable national disposal regulations as regards environmentally compatible disposal of the frequency inverter. For more details, contact the competent local authorities.

3 Introduction

The present document describes the Modbus/TCP protocol for the CM-Modbus/TCP and CM-Modbus/TCP-2P (switch function integrated) communication modules. After connecting Modbus/TCP to the PLC, you can use an additional logic connection from CM-Modbus/TCP to the VPlus software running on a terminal connected via an Ethernet network.

For Modbus/TCP connection, the frequency inverter must be equipped with the CM-Modbus/TCP or CM-Modbus/TCP-2P communication module.

The CM-Modus/TCP and CM-Modbus/TCP-2P communication modules are separate components and must be attached to the frequency inverter. This is described in chapter 6.1 “Assembly”.

Modbus/TCP communication (as described in this manual) requires software version 6.2.0 or higher.

This manual only describes the CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules. This manual is not to be understood as providing general/basic information on Ethernet interfaces or frequency inverters.
General/basic knowledge of the methods and function of Modbus/TCP interfaces and Modbus/TCP protocol are a prerequisite for understanding and implementing the instructions provided by this document.

In some chapters of these instructions, setting and display options via the PC software VPlus are described as an alternative to the control unit. In this case, VPlus can use

- CM-Modbus/TCP or CM-Modbus/TCP-2P module **or**
- the serial interface.

for communication with the frequency inverter.

The module enables using Modbus/TCP and VPlus via the VABus/TCP protocol at the same time.

⚠ WARNING

With CM-Modbus/TCP or CM-Modbus/TCP-2P, controllers can access **all** parameters of the frequency inverter.

Changing parameters the function of which is unknown can result in malfunction of the frequency inverter and dangerous situations in the plant.

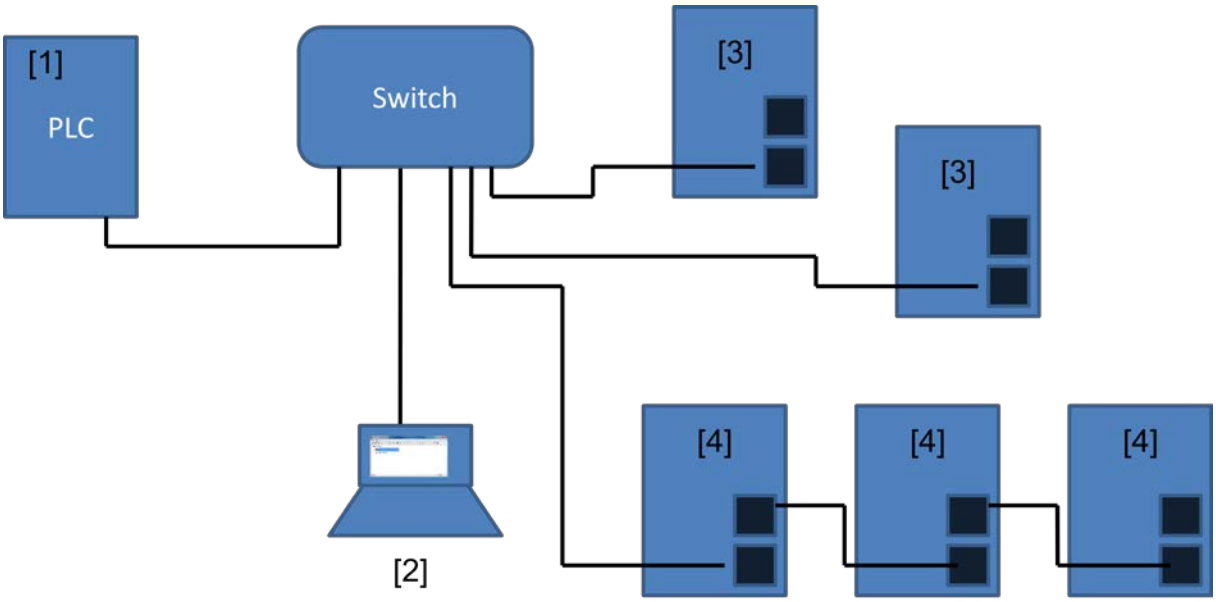
Module variants:

There are two Modbus/TCP variants.

CM-Modbus/TCP provides a physical interface for communication via Modbus/TCP. A star-type network topology can be used. An external switch is the star point.

CM-Modbus/TCP-2P provides two physical interfaces for communication via Modbus/TCP. The following network topologies are possible:

- Star-type (like in CM-Modbus/TCP)
- Line



[1] PLC
[2] PC for commissioning or diagnosis (connected temporarily or permanently)
[3] AGL with CM-Modbus/TCP or CM-Modbus/TCP-2P (2nd port not connected)
[4] AGL with CM-Modbus/TCP-2P

3.1 Supported configurations

Agile frequency inverters support various types of control and reference point input:

- Contacts or remote contacts
- State machine

Contacts or remote contacts
Required settings: *Local/Remote* **412** = (remote) contacts

➔ Control (start, stop, frequency changeover, etc.) is typically performed through
  - digital contacts.
  - Remote contacts via field bus.

➔ Reference values depend on the selected function. Typical:
  - Reference speed/reference frequency:
    - Analog input.
    - Fixed values from parameters.
  - Reference percentage for technology controller or torque control
    - Analog input.
    - Fixed values from parameters.

See Chapter 11 “Control of frequency inverter”.

State machine:
Required settings: *Local/Remote* **412** = 1 – State machine

➔ Control (start, stop, change of mode, etc.) is performed via *Control word* **410**.

➔ Reference values depend on the selected function. Typical:
  - Reference speed/reference frequency:
    - Analog input.
    - Fixed values from parameters.
  - Reference percentage for technology controller or torque control
    - Analog input.
    - Fixed values from parameters.

3.2 Initialization time

When the frequency inverter is turned on, the communication module must be initialized in addition to the frequency inverter. The initialization can take up to 20 seconds.

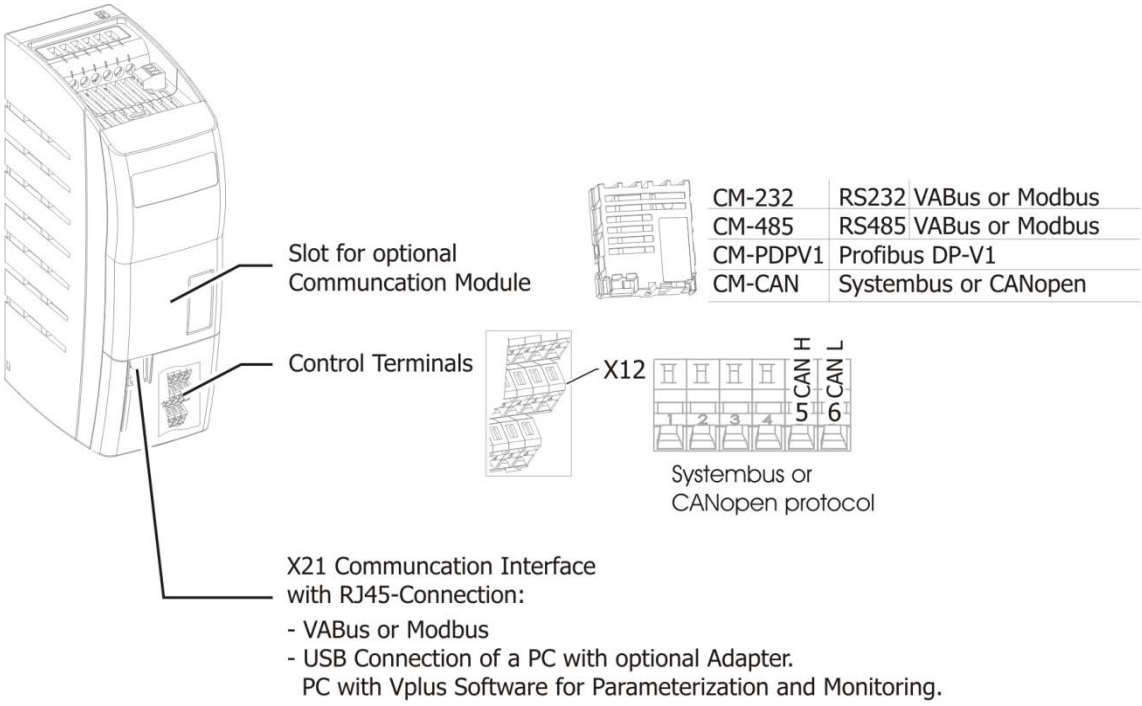
Wait until the initialization phase is complete before starting the communication (RUN LED).

4 First commissioning

For first commissioning, you should be familiar with the followings steps and the described functions:

- Installation of module — Chapter 6.1
- Selection of device control *Local/Remote* **412** — Chapter 11
- Commissioning of device functions via PLC
  - Fault Reaction — Chapter 7.3
    - Fault reset — Chapter 8.3, 14.5
- Setting reference values
  - Reference Frequency — Chapter 11.3.2
- Diagnosis — Chapter 13, 14.1

5 Communication options



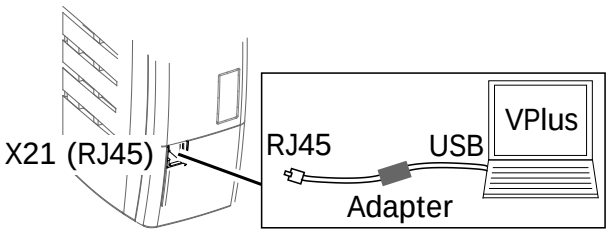
Interface	See
CAN connection control terminals	Instructions on Systembus or CANopen®.
CM-CAN	
Communication interface X21	Instructions on VABus or Modbus.
CM-232	Instructions on VABus or Modbus.
CM-485	Instructions on VABus or Modbus.
CM-PDPV1	Instructions on Profibus DP-V1.
CM-DEV	Instructions on DeviceNet.
CM-VABus/TCP	Instructions on VABus/TCP.
CM-EtherCAT	Instructions on EtherCAT®.
CM-EtherNet/IP	Instructions on EtherNet/IP.
CM-Modbus/TCP	Instructions on Modbus TCP.
CM-PROFINET	Instructions on PROFINET.

Combinations of Systembus and CANopen® communication at the two interfaces:

Optional communi-cation module (CM)		Frequency inverter terminals X12.5 and X12.6
CANopen®	and (at the same time)	Systembus
Systembus	and (at the same time)	CANopen®

5.1 Control software VPlus:

Via an optional USB adapter, you can connect an USB interface of a PC to the X21 communication interface. This enables configuration and monitoring using the PC software VPlus.



6 Assembly / disassembly of communication module

6.1 Assembly

The CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules are pre-assembled in a case and are ready for installation. In addition, a PE-spring is supplied for PE-connection (shield).

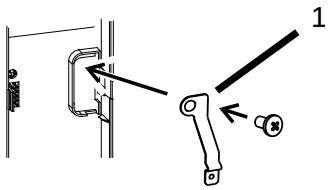
⚠ CAUTION

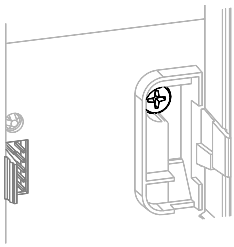
Danger of destruction of frequency inverter and / or communication module

- Before installation of the communication module, the frequency inverter must be disconnected from power supply. Installation is not permissible while the unit is energized.
- Do not touch the PCB visible on the back of the module, otherwise components may be damaged.

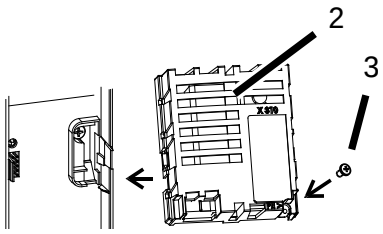
Work steps:

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Remove the cover of the module slot.
- Fix the PE-spring (1). Use the screw provided at the frequency inverter.





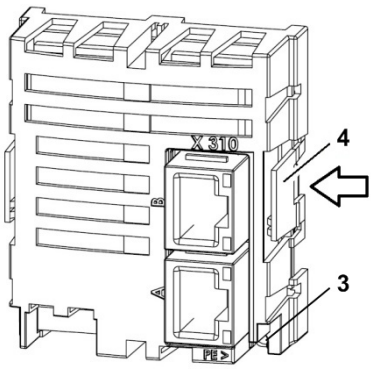
- Insert the communication module.
- Fix the communication module (2) at the frequency inverter using the screw (3).



- Break out the pre-punched cut-out from the cover.
- Fix the cover again.

6.2 Disassembly

- Disconnect the frequency inverter from power supply and protect it against being energized unintentionally.
- Remove the cover of the module slot.
- Loosen the screw (3) at the communication module.
- Using a small screwdriver, unlock the hooks (4) (first right then left).

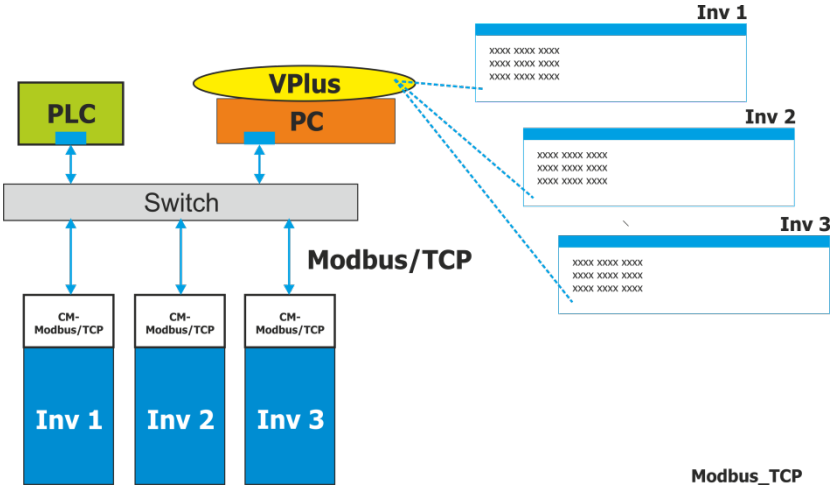


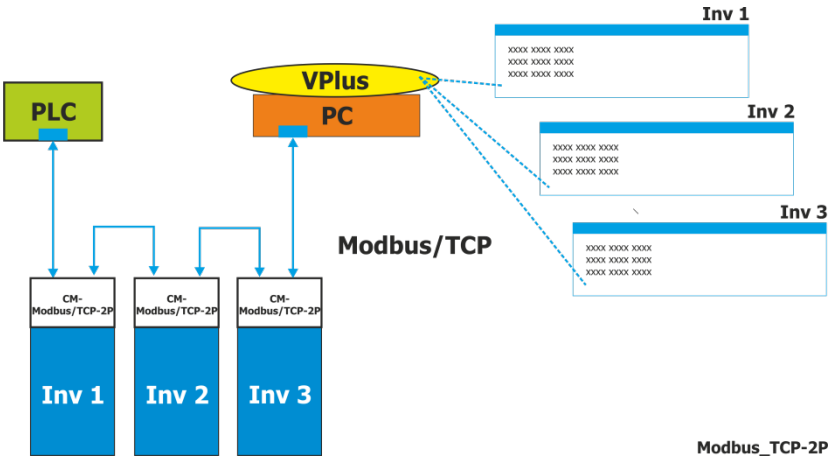
- Pull communication module out of slot.
- Unscrew PE-spring.
- Fix the cover on the frequency inverter.

7 Modbus/TCP interface

The frequency inverter can be controlled by a PLC or another master device via an Ethernet interfaces using the Modbus/TCP protocol.

When a Modbus/TCP or Modbus/TCP-2P communication module is used, you can also access the frequency inverter using the VPlus software via Ethernet. VPlus can be used in parallel with a PLC with Modbus/TCP communication.





This document does not provide basic information about Ethernet interfaces. Basic knowledge of the Modbus/TCP protocol and Ethernet interfaces is required.

In some sections, setting and display options via the PC software VPlus are described as an alternative to the control unit. In this case, VPlus communicates with the frequency inverter via the X21 connection or a direct Ethernet connection.

⚠ WARNING

With Modbus/TCP communication, controllers can access **all** parameters of the frequency inverter.

Changing parameters the function of which is unknown can result in malfunction of the frequency inverter and dangerous situations in the plant.

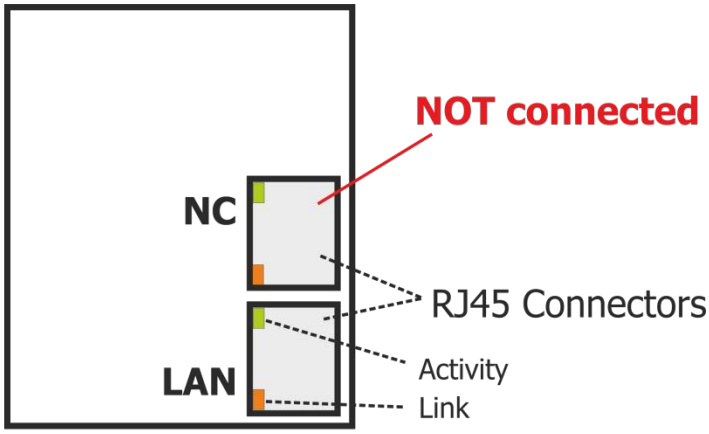
⚠ CAUTION

When values are to be written cyclically at a high repetition rate, no entries shall be made in the EEPROM, as this only allows a limited number of write cycles (approx. 1 million cycles). If the number of permissible write cycles is exceeded, the EEPROM will be damaged. See chapter 9.1 “Handling of datasets / cyclic writing of parameters”.

7.1 Communication modules

CM-Modbus/TCP

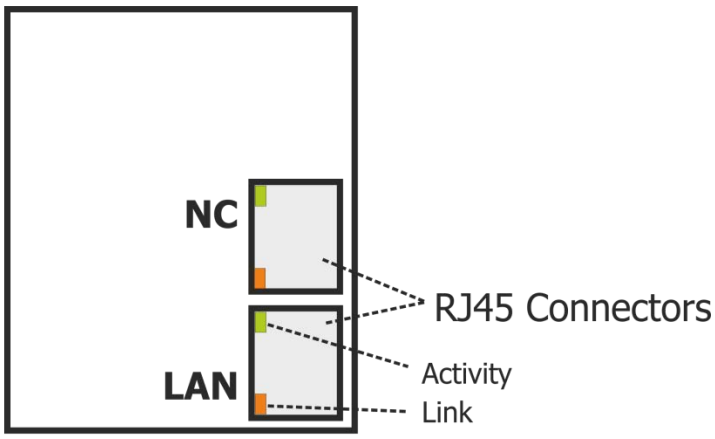
The CM-Modbus/TCP communication module features an active RJ45 port.



CM-Modbus/TCP

CM-Modbus/TCP-2P

The CM-Modbus/TCP-2P communication module features two active RJ45 ports with integrated switching function. This enables easy linking (daisy chain) of frequency inverters which are connected to a PLC.



CM-Modbus/TCP

7.1.1 Installation instructions

The Modbus/TCP module is connected to the PLC or other devices using standard CAT cables and RJ45 connectors:

Ethernet standard:	IEEE 802.3, 100Base-TX (fast Ethernet)
Cable type:	S/FTP (cable with braided shield, (ISO/IEC 11801 or EN 50173, CAT5e Straight Through of Cross Over)

7.2 Setup

By default, the parameters of the CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules are set up as follows:

Parameters		Settings
No.	**Description**	**Factory setting**
388	*Bus Error Behaviour*	1
1432	*IP-Address*	172.22.1.25
1433	*Netmask*	255.255.255.0
1434	*Gateway*	0.0.0.0
1435	*DNS Server*	0.0.0.0
1436	*DHCP Option*	0
1437	*IP Command*	-
1440	*Email Function*	0
1441	*Email Text (Body)*	-
1439	*Modbus/TCP Timeout*	0

The parameter settings must be adapted to the actual application.

7.2.1 TCP/IP configuration

For the configuration of the IP address, Netmask, etc., refer in the CM-VABus/TCP operating instructions to Chapter “TCP/IP configuration”.

7.2.2 TCP/IP address & Subnet settings

For proper identification, each frequency inverter is assigned a TCP/IP address which must be unique in the system.

7.2.2.1 Network without DHCP server:

The address is set via parameter *IP-Address* **1432**. In addition, the subnet mask *Netmask* **1433** must be entered properly for the local network.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1432	IP Address	0.0.0.0	255.255.255.255	172.22.1.25
1433	Netmask	0.0.0.0	255.255.255.255	255.255.255.0

7.2.2.2 Network with DHCP server:

When a DHCP server is used, manual network configuration is not required. Set *DHCP Option* **1436** to “1-Enabled” if you wish to use the DHCP function.

DHCP Option **1436**	Function
0 - Disabled	Module must be configured manually, no DHCP server is used. (**Factory setting**).
1 - Enabled	The settings are made by a DHCP server.

7.2.3 Modbus/TCP Timeout settings

The communication can be monitored: If communication fails, no data or faulty data will be transmitted. The Modbus/TCP Timeout feature will identify this state.

The timeout feature monitors communication for the time defined by parameter *Modbus/TCP Timeout* **1439**. The set value represents the time in milliseconds where correct data transfer must take place.

If no data is transferred correctly within this time, the frequency inverter will signal the fault **F2735 Modbus/TCP Timeout**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1439	Modbus/TCP Timeout	0 ms	60000 ms	0 ms

When the parameter is set to 0 (factory setting), the monitoring function is off.

7.3 Operating behavior in the case of a communication error

The operating behavior in the case of errors in Modbus/TCP communication can be parameterized. The required behavior can be set up via parameter *Bus Error Behaviour* **388**.

Bus Error Behaviour 388	Function
0 -no response	Operating point is maintained.
1 -Error	"Fault" status will be activated immediately. **Factory setting**.
2 -Stop	Control command "Disable voltage" and switch to "switch on disabled" status.
3 -Quick stop	Control command "Quick stop" and switch to "switch on disabled" status.
4 -Shutdown + Error	Control command "Disable operation" and switch to "Error" status once the drive has been shut down.
5 -Quick stop + Error	Control command "Quick stop" and switch to "Error" status once the drive has been shut down.

The parameter settings *Bus Error Behaviour* **388** = 2...5 are evaluated depending on parameter *Local/Remote* **412**.

For correct evaluation, parameter *Local/Remote* **412** must be set to value "1 - Control via statemachine".

8 Protocol

The Modbus/TCP communication protocol is a Client/Server based protocol. Modbus/TCP communication will always be initialized by the client (e.g. PLC). The server nodes (frequency inverters) do not communicate with one another.

Modbus/TCP communication will be established by the client via the TCP/IP-Port #502 on the side of the Modbus/TCP server.

CM-Modbus/TCP and CM-Modbus/TCP-2P only support

- Port #502 for establishing Modbus/TCP connection
- one request per transaction only (NumberMaxOfServerTransaction = 1)

8.1 Telegram structure

A Modbus telegram comprises the following fields:

MBAP	Function code	Data (Modbus RTU data contents)

MBAP Modbus Application Header

Field	**Length**	**Description**	**Client**	**Server (inverter)**
Transaction ID (transaction identifier)	2 bytes	Identification of Modbus request/response transaction	Initialized by client	Written back by the server from the request received
Protocol ID (protocol identifier)	2 bytes	0 = Modbus protocol	Initialized by client	Written back by the server from the request received
Length	2 bytes	Number of subsequent bytes (including ID of data unit)	Initialized by client (request)	Initialized by server (response)
ID of data unit (unit identifier)	1 byte	Identification of serially connected Remote Slave	Initialized by client (request)	Initialized by server (response)

- The data unit identifier will not be processed by the server.
- The function code and data field structure are the same in Modbus/TCP and Modbus-RTU.
- Modbus/TCP uses byte sequence Big-Endian (Motorola format).

The **function code** tells the server/frequency inverter which action is to be performed. The function code is followed by a data field containing the parameters of the request (or the response parameters in the case of the response by the frequency inverter).

If there are no errors while a request is received via Modbus, the data field will contain the required data. If an error occurs, the field contains an exception condition code to tell the master that the request was not processed successfully. For information on how to handle exception conditions and the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

8.2 Supported function codes

The Modbus definitions for writing and reading of data are not directly compatible with parameter access by a frequency inverter (irrespective of the manufacturer of the frequency inverter). Modbus is designed for reading bits and captures data in a different way. Data access is limited to a bit width of 16.

In order to meet the requirements of Modbus, data access is defined in the frequency inverters by the following function codes.

16-bit values:

- Function code 3, read ONE data width of 16 bits (reading of hold register)
- Function code 6, write ONE data width of 16 bits (writing of single register)
- Function code 16, read ONE data width of 16 bits (writing of multiple registers)

32-bit values:

For access to 32-bit data, frequency inverters use the following adapted function codes:

- Function code 3, read TWO data widths of 16 bits (=32 bits) (reading of hold register)
- Function code 16, write TWO data widths of 16 bits (=32 bits) (writing of multiple registers)
- Function code 100, read ONE bit width 32
- Function code 101, write ONE bit width 32

The Modbus specification does not describe handling of 32-bit values. The implemented handlings and function codes are quite common and frequently used. These functions enable data access to 32-bit “Long” variables in the frequency inverter.

In all data fields containing more than one byte, the highest-value byte will be transferred firs (Big-Endian, Motorola Format).

8.2.1 Function code 3, reading 16-bit or 32-bit parameters

This function code is used for reading 16-bit or 32-bit values from the frequency inverter.

Request Read 16-bit parameter :

Function code	1 byte	0x03
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001

Response Read 16-bit parameter :

Function code	1 byte	0x03
Number of bytes	1 byte	0x02
Register value (parameter value)	2 bytes	0 – 0xFFFF

Request Read 32-bit parameter :

Function code	1 byte	0x03
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002

Response Read 32-bit parameter :

Function code	1 byte	0x03
Number of bytes	1 byte	0x04
Register value (parameter value)	4 bytes	0 – 0xFFFFFFFF

Exception condition response:

Error code	1 byte	0x83
Exception condition code	1 byte	2, 3 or 4

Start address

This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:

Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Number of registers

This field is used for saving the number of parameters to be written. The value must always be 1, since only one parameter can be written at a time.

Number of bytes

This field is set to

- 2 for 16-bit parameters
- 4 for 32-bit parameters

Register value

This field contains the 16-bit or 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A current value of 10.3 A is transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Value of register number field is not 1 • Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

Example Telegrams:

	16 Bit	32 Bit
Modbus RTU	see chapter 10.1.1	see chapter 10.2.1

8.2.2 Function code 6, write 16-bit parameter

This function code is used for writing integer or unsigned integer values into the frequency inverter.

Request Write 16-bit parameter :

MBAP header	7 bytes	
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x06
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	2 bytes	0 – 0xFFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x06
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	2 bytes	0 – 0xFFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x86
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 16-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A current value of 10.3 A is to be transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 10.1.2.

8.2.3 Function code 16, write 16-bit parameter

Function code 16 can be used for writing 16-bit values into the frequency inverter.

Request Write 16-bit parameter :

MBAP header	7 bytes	
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001
Number of bytes	1 byte	0x02
Register value (parameter value)	2 bytes	0 – 0xFFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x90
Exception condition code	1 byte	2, 3 or 4

Start address

This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:

Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value

This field is used for saving the 16-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:

A current value of 10.3 A is to be transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 10.1.3.

8.2.4 Function code 16, write 32-bit parameter

Function code 16 can be used for writing 32-bit values into the frequency inverter.

Request Write 32-bit parameter :

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002
Number of bytes	1 byte	0x04
Register value (parameter value)	2 bytes	0 – 0xFFFF FFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x90
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:

Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A frequency value of 123.45 Hz is to be transferred. The actually transferred numerical value is 12345, i.e. 0x3039 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 10.2.2.

8.2.5 Function code 100 (=0x64), read 32-bit parameter

Request:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x64
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x64
Register value (parameter value)	4 bytes	0 – 0x FFFF FFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0xE4
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter 372 (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Number of registers
This field is used for saving the 32-bit parameter values.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A frequency value of 100.25 Hz is to be transferred. The actually transferred numerical value is 10025, i.e. 0x2729in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 10.2.3.

8.2.6 Function code 101 (=0x65), write 32-bit parameter

Request:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x65
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	4 bytes	0 – 0xFFFF FFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x65
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	4 bytes	0 – 0xFFFF FFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0xE5
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example: Frequency value
A frequency value of 100.25 Hz is to be transferred. The actually transferred numerical value is 10025, i.e. 0x2729 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 10.2.4.

8.2.7 Function code 8, diagnosis

This function code is used for accessing the Modbus diagnosis counter of the frequency inverter. Each counter can be accessed via a sub-function code and a counter number. Each counter can be deleted by entering the hexadecimal sub-function code 0x0A.

The following sub-function codes are supported.

Sub-function	Name	Description
0x0A	Delete all counters	Resets all counters to 0
0x0B	Return number of bus messages	Number of valid messages received (including all addresses)
0x0C	Return number of bus transfer errors	Number of messages with CRC or parity/block check/data loss errors
0x0D	Return number of bus exceptions	Number of exception responses sent
0x0E	Return number of slave messages	Number of messages received (including slave address)
0x0F	Return number of “Slave – no response” messages	Number of broadcast messages received
0x10	Return number of slave NAK (negative receipt acknowledgment)	Not used, return value will always be 0
0x11	Return number of “Slave busy” messages	Not used, return value will always be 0
0x12	Return number of bus character data loss error	Number of messages with data loss errors

Request (sub-function 0x0A, Delete all counters):

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000A
Data	2 bytes	0x0000

Response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000A
Data	2 bytes	0x0000

Exception condition response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x88
Exception condition code	1 byte	1, 3 or 4

Data
This field will always be 0x0000.

Exception condition code

1	INVALID FUNCTION CODE	• Sub-function is not supported
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high • “Data field” not 0x0000
4	SLAVE DEVICE ERROR	• Error while executing the function.

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

Request (sub-function 0x0B – 0x12, return counter value):

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000B – 0x0012
Data	2 bytes	0x0000

Response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000B – 0x0012
Data (counter value)	2 bytes	0 – 0xFFFF

Exception condition response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x88
Exception condition code	1 byte	1, 3 or 4

Data
In the request, this field will always be set to 0x0000, in the response, it will show the current counter value.

Exception condition code
The following exception condition codes are possible:

1	INVALID FUNCTION CODE	• Sub-function is not supported
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high • “Data field” not 0x0000
4	SLAVE DEVICE ERROR	• Error when reading diagnosis counter

For a description of the exception condition codes, refer to Chapter 8.2.9 “Exception condition codes”.

8.2.8 Exception condition responses

The master device expects a normal response when it sends a request to the frequency inverter. A request by the master can result in one of four reactions:

- If the frequency inverter receives the request without any transmission errors, it can process it and send a normal response.
- If the frequency inverter does not receive the request due to a transmission error, it will not send a response. The master will check the conditions for time monitoring of the request.
- If the frequency inverter receives the request and identifies a transmission error (parity, LCR, CRC, ...), it will not send a response. The master will check the conditions for time monitoring of the request.
- If the frequency inverter receives the request without any transmission error, but cannot process it, e.g. because an unknown parameter is to the read, it will send an exception response containing information about the type of error.

The exception condition response contains two fields which are different from normal responses:

Function code field:
In a normal response, the frequency inverter will return the function code of the original request. All function codes have 0 as the most significant bit (SB); their values are less than the hexadecimal value of 0x80. In an exception condition response, the frequency inverter will set the most significant bit of the function code to 1. This will increase the hexadecimal value of the function code in an exception condition response by 0x80 compared to the value of a normal response. With the most significant bit in the function code set to the new value, the master can identify the exception response and analyze the exception condition code in the data field.

Data field:
In a normal response, the frequency inverter will send data or statistical values in the data field (requested information) . In an exception condition response, the frequency inverter will send an exception condition code in the data field. This code indicates the cause of the exception condition.

The exception condition codes generated by the frequency inverter are listed in Chapter 8.2.9 “Exception condition codes”.

8.2.9 Exception condition codes

The frequency inverter generates the following exception condition codes:

Code	Modbus name	Reason of generation by frequency inverter
1	INVALID FUNCTION	• Function code unknown • Sub-function code unknown (diagnosis function)
2	INVALID DATA ADDRESS	• Wrong number of registers (must always be 0x01) • Unknown parameter or data type of parameter unknown
3	INVALID DATA VALUE	• Block check error • Number of bytes in too small or too high • Certain fields not set to typical values
4	SLAVE DEVICE ERROR	• Unsuccessful reading or writing of parameters The cause of the error can be analyzed by reading parameter *VABusSST Error Register* **11**.

VABusSST Error Register **11**	
Error number	**Meaning**
0	No error
1	Non-permissible parameter value.
2	Non-permissible dataset
3	Parameter not readable (write-only)
4	Parameter not writable (read-only)
5	EEPROM read error
6	EEPROM write error
7	EEPROM checksum error
8	Parameter cannot be written while the drive is running
9	Values of data sets are different
10	Wrong parameter type
11	Unknown parameter
12	Checksum error in received telegram
13	Syntax error in received telegram
14	Data type of parameter does not match the number of bytes in the telegram
15	Unknown error

When parameter *VABusSST Error Register* **11** is read, it is deleted automatically at the same time.

8.2.10 Modbus transmission mode

The usable contents of Modbus/TCP is basically structured like Modbus RTU.

8.2.10.1 Modbus RTU message telegram

Modbus messages are added by a sending device into a telegram which has a defined start and end point. The TCP/IP frame enables receiving devices to identify the beginning and end of the message. Incomplete messages must be detected and result in an error.

Modbus message

Address	Function	Data
8 bits	8 bits	N x 8 bits

The whole message telegram must be transmitted as a coherent flow of characters.

8.3 Resetting errors

Depending on the settings and operating state of the device, errors can be reset in different ways:

- In controller via Parameter *Local/Remote* **412** = 1 - Statemachine:
  Set bit 7 *Control word* **410** = 0x8000.
- By pressing the stop button of the control panel:
  Resetting by pressing the STOP button is only possible if Parameter *Local/Remote* **412** permits control via the control panel.
- Via parameter *Error acknowledgment* **103** which is assigned a logic signal or a digital input
  A reset via a digital signal can only be carried out when parameter *Local/Remote* **412** permits this or when an input with the addition (hardware) is selected in the case of physical inputs.

Some errors will occur again after an error reset. In such cases, it may be necessary to take certain measures (e.g. moving from a limit switch in the non-disabled direction).

9 Parameter access

9.1 Handling of datasets / cyclic writing of parameters

The parameter values are accessed based on the parameter number and the required dataset. There are parameters the values of which are present once (dataset 0) as well as parameters the values of which are present four times (dataset 1...4). These are used for dataset switching.

If parameters which are present four times in the datasets are set to Dataset = 0, the four datasets are set to the same transmitted value. A read access with data set = 0 to such parameters is only successful if all four data sets are set to the same value. If this is not the case, an error will be signaled.

NOTE

The values are entered automatically in the EEPROM of the controller. When values are to be written cyclically, no entries shall be made in the EEPROM, as this only allows a limited number of write cycles (approx. 1 million cycles). When the number of permissible write cycles is exceeded, the EEPROM will be destroyed.

In order to avoid this, data which is written cyclically can be entered in the RAM exclusively without a writing cycle on the EEPROM. Such data will be lost in the case of a power failure and have to be written again after Power off/on.
This mechanism is started when the target dataset is increased by five when specifying the dataset.

Writing on virtual dataset in RAM

Parameters	EEPROM	RAM
Dataset 0	0	5
Dataset 1	1	6
Dataset 2	2	7
Dataset 3	3	8
Dataset 4	4	9

9.2 Handling index parameters / cyclic writing

Index parameters are used for various frequency inverter functions. Here, 16 or 32 indexes are used instead of the 4 data sets. For each function, the individual indexes are addressed separately via an index access parameter. Via the indexing parameter, you can select if the data is to be written to EEPROM or RAM.

Function	Parameters	Index range		Indexing parameters
		Write EEPROM and read	Write RAM	
PLC function (Function Table)	**1343** *FT-Instruction* **1344** *FT-Input 1* **1345** *FT-Input 2* **1346** *FT-Input 3* **1347** *FT-Input 4* **1348** *FT-Parameter 1* **1349** *FT-Parameter 2* **1350** *FT-Target Output 1* **1351** *FT-Target Output 2* **1352** *FT-Commentary*	0[1)]; 1...32	33[1)]; 34...65	**1341** Write **1342** Read
Multiplexer	**1252** *Mux Input*	0[1)]; 1...16	17[1)]; 18...33	**1250** Write **1251** Read
CANopen® Multiplexer	**1422** *CANopen Mux Input*	0[1)]; 1...16	17[1)]; 18...33	**1420** Write **1421** Read

1) When the indexing parameter = 0, all indexes will be written upon parameter access in EEPROM. 17 or 33 will write all indexes in RAM.

NOTE

The values are entered automatically in the EEPROM of the controller. However, only a limited number of write cycles is permissible for the EEPROM (approx. 1 million cycles). When this number is exceeded, the EEPROM will be destroyed.

- Values which are written cyclically at a high repetition rate should be written to the RAM and not the EEPROM.

In the RAM, the data is not protected against loss of power. Once power supply is disrupted, the data must be written again.
This procedure is started when the target data set is increased by five when specifying the data set (IND).

9.3 Example: Writing of index parameters

Typically, index parameters are written during commissioning.

Writing of Parameter **1344** *PLC Input 1* (Type int), in Index 34 in RAM (→ Index 34 for write access) with parameter value 2380.
Index = 1341 + 0x2000 = 0x253D, value (int) = 34 = 0x0022
Index = 1344 + 0x2000 = 0x2540, value (int) = 2380 = 0x094C

If various parameters in an index are to be edited, it will be sufficient to set index access via **1341** once first.

9.4 Example: Reading of index parameters

In order to read an index parameter, you will have to set the indexing parameter to the relevant index first, then you can read the parameter.

Reading from parameter *PLC input 1* **1344** type int), in Index 1 with parameter value 6.
Index = 1342 + 0x2000 = 0x253E, value (int) = 1 = 0x0001
Index = 1344 + 0x2000 = 0x2540, value (int) = 6 = 0x0006

If various parameter of an index are to be read, it will be sufficient to set index access via **1342** once first.

10 Example messages Modbus/TCP

This chapter describes some examples of telegrams for Modbus/TCP.

10.1 16-bit access

10.1.1 Function code 3, read 16-bit parameter

Example 1:
Reading of parameter *Rated speed* **372** (0x0174) in data set 2 from the frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Number of registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	03	21	74	00	01

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	No. Bytes	Par.value	
	Transaction ID		Protocol ID		Length						
Hex	nn	nn	nn	nn	nn	nn	01	03	02	05	6E

The sent hexadecimal value is 0x056E = Decimal 1390. Parameter *Rated speed* **372** has no decimal places. Thus, the rated speed is 1390 min^{-1}.

Example 2:
Reading of parameters *Rated speed* **372** (0x0174) in dataset 0 of frequency inverter with address set to 1 and number of registers set to 2 (non-permissible value).

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Number of registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	03	01	74	00	02

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	83	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.1.2 Function code 6, write 16-bit parameter

Example 1:
Writing of parameter *Rated Mech. Power* **376** (0x0178) in dataset 4 of frequency inverter with address 3.

The rated mechanical power is to be set to 1.50 kW. Parameter *Rated Mech. Power* **376** has two decimal places. Thus the value to be sent is 150 = 0x0096.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	06	41	78	00	96

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	06	41	78	00	96

The response is the reflected signal of the request message.

Example 2:
Writing of non-permissible value 0 in parameter *Rated Mech. power* **376** (0x0178) in dataset 2 of frequency inverter with address 3.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	03	06	21	78	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	03	86	04

The sent exception condition code is the hexadecimal value 0x04 = Error SLAVE device.

10.1.3 Function code 16, write 16-bit parameter

Example 1:
Writing of parameter *Rated mech. power* 376 (0x0178) in dataset 4 of frequency inverter with address 1.

The rated mechanical power is to be set to 1.50 kW. Parameter *Rated mech. Power* **376** has two decimal places. Thus the value to be sent is 150 = 0x0096.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers		No. Byte	Par. value	
	Transaction ID		Protocol ID		Length										
	nn	nn	nn	nn	00	09	01	10	41	78	00	01	02	00	96

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	09	01	10	41	78	00	01

The response contains the number of written registers

Example 2:
Writing of non-permissible value 0 in parameter *Rated mech. power* **376** (0x0178) in dataset 2 of frequency inverter with address 3.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers		No. Byte	Par. value	
	Transaction ID		Protocol ID		Length										
	nn	nn	nn	nn	00	09	03	10	41	78	00	01	02	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	03	90	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.2 32-bit access

10.2.1 Function code 3, read 32-bit parameter

Example 1:
Reading of parameter *Fixed Frequency 2* **481** (0x01E1) in dataset 1 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	06	01	03	11	E1	00	02

Response: Frequency inverter ➔ Master

Field:	MBAP						Addi.	Func.	No. Bytes	Par.value			
	Transaction ID		Protocol ID		Length								
Hex	nn	nn	nn	nn	00	07	01	03	04	00	00	03	E8

The sent hexadecimal value is 0x03E8 = Decimal 1000. Parameter *Fixed Frequency 2* **481** has two decimal places. Thus, the frequency is 10.00 Hz.

Example 2:
Reading of parameters *Fixed Frequency 2* **481** (0x01E1) in dataset 0 of frequency inverter with address set to 1 and number of registers set to 1 (non-permissible value).

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	06	01	03	01	E0	00	01

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	83	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.2.2 Function code 16, write 32-bit parameter

Example 1:
Writing of parameter *Fixed Frequency 3* **482** (0x01E2) in dataset 9 (= RAM for dataset 4) of frequency inverter with address 1.

The fixed frequency is to be set to 44.50 Hz. Parameter *Fixed Frequency 3* **482** has two decimal places. Thus the value to be sent is 4450 = 0x00001162.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers		No. Byte	Par. value			
	Transaction ID		Protocol ID		Length												
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02	04	00	00	11	62

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02

The response contains the number of written registers

Example 2:
Writing of parameter *Fixed Frequency 3* **482** (0x01E2) in dataset 9 (= RAM for dataset 4) of frequency inverter with address 1.

The frequency is to be set to 2000.00 Hz (non-permissible value). Parameter *Fixed Frequency 3* **482** has two decimal places. Thus the value to be sent is 20000 = 0x00030D40.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers		No. Byte	Par. value			
	Transaction ID		Protocol ID		Length												
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02	04	00	03	0D	40

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	90	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.2.3 Function code 100 (=0x64), read 32-bit parameter

Example 1:
Reading of parameter *Fixed Frequency 2* **481** in dataset 0 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.	
	Transaction ID		Protocol ID		Length					
Hex	nn	nn	nn	nn	00	04	01	64	01	E1

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Par. value			
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	64	00	00	03	E8

The sent hexadecimal value is 0x000003E8 = 1000. Parameter *Fixed Frequency 2* **481** has two decimal places. Thus, Fixed Frequency 2 = 10.00 Hz.

Example 2:
Reading of unknown parameter **1600** (0x0640) in dataset 2 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.	
	Transaction ID		Protocol ID		Length					
Hex	nn	nn	nn	nn	00	04	01	64	26	40

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	E4	04

The exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.2.4 Function code 101 (=0x65), write 32-bit parameter

Example 1:
Writing of parameter *Rated Frequency* **375** (0x0177) in dataset 2 of frequency inverter with address 1.

The Rated Frequency is to be set to 10.00 Hz. Parameter *Rated Frequency* **375** has two decimal places. Thus the value to be sent is 1000 = 0x03E8.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	E8

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	E8

The response is the reflected signal of the request message.

Example 2:
Writing of non-permissible value 9.00 Hz in parameter *Rated Frequency* **375** in dataset 2 of frequency inverter with address 1.

Parameter *Rated Frequency* **375** has 2 decimal places. Thus the value to be sent is 900 = 0x0384.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	84

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	E5	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

10.2.5 Function code 8, diagnosis

Example 1a:
Deleting of all diagnosis counters (sub-function 0x0A) in frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0A	00	00

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0A	00	00

The response is the reflected signal of the request message. All counters are set to zero.

Example 1b:
With all counters set to zero, reading of diagnosis counter 4 “Slave Messages Counter” (sub-function 0x0E) of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0E	00	00

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0E	00	01

Counter value is 1 because this is the first message received after resetting of all counters to zero.

Example 2:
Reading of unknown diagnosis counter 8 (sub-function 0x13) of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	13	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	88	01

The sent exception condition code is the hexadecimal value 0x01 = INVALID FUNCTION CODE.

11 Control of frequency inverter

The frequency inverter can generally be controlled via three operation modes. The operation modes can be selected via the data set switchable parameter *Local/Remote* **412**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
412	Local/Remote	0	44	44

For operation with Modbus/TCP, only operation modes 0, 1 and 2 are relevant. The other settings refer to the control option via the control panel.

Operation mode	Function
0 - Control via contacts (Chapter 11.1)	The Start and Stop commands as well as the direction of rotation are controlled via digital signals.
1 - Control via state machine (Chapter 11.2)	The frequency inverter is controlled via the control word.
2 - Control via remote contacts (Chapter 11.1)	The Start and Stop commands as well as the direction of rotation are controlled via virtual digital signals of the control word.

Parameter *Local/Remote* **412** is dataset switchable, i.e. you can switch between the different operation modes by selecting another data set. For example, a frequency inverter can be controlled via the bus, and emergency mode can be activated locally when the bus master fails. This switch-over is also identified by the status word (remote bit).

The data set switching can be effected locally via control contacts at the digital inputs of the frequency inverter or via the bus. For data set switching via the bus, parameter *Data set selection* **414** is used.

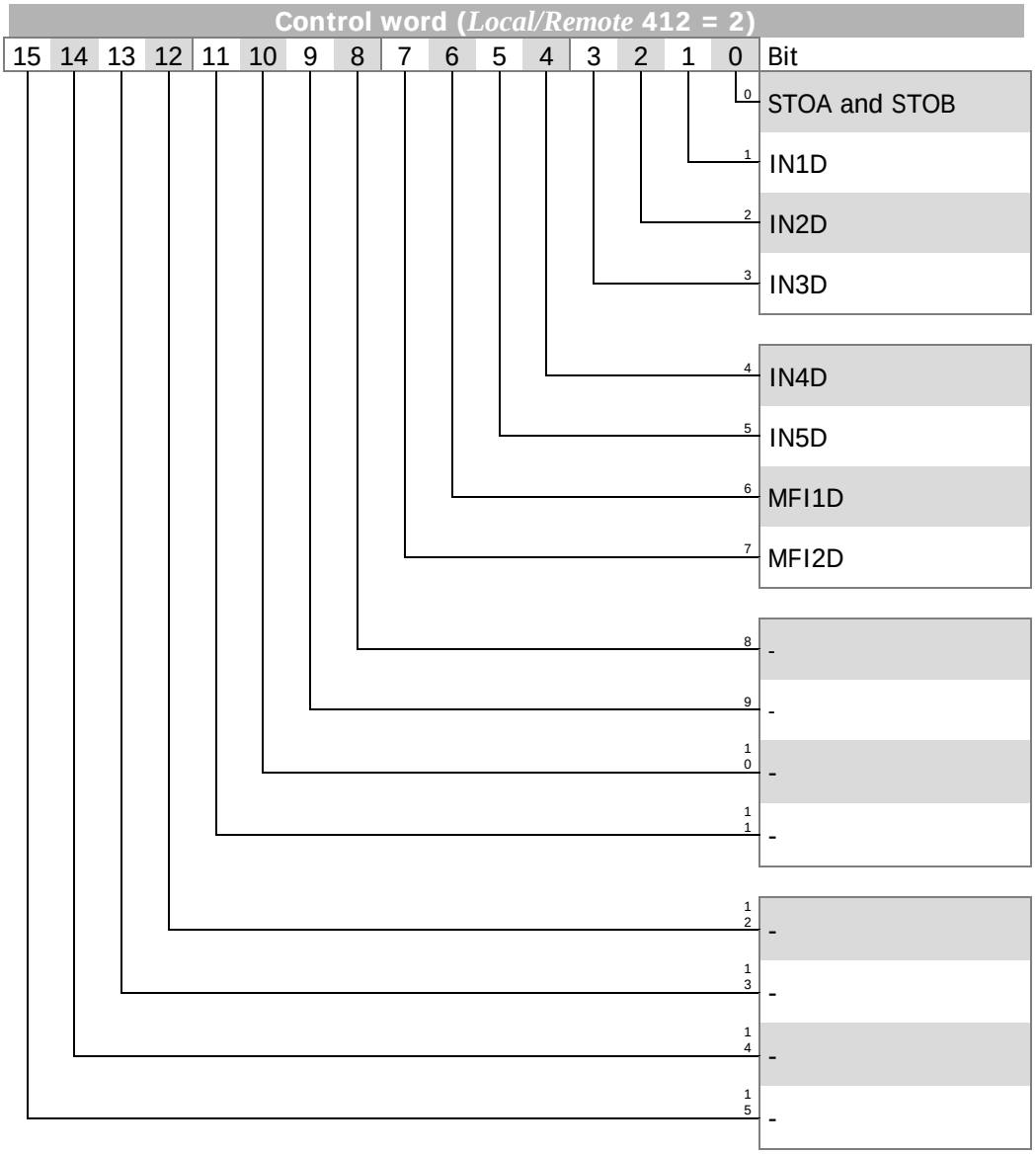
Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
414	Data set selection	0	5	0

With *Data set selection* **414** = 0, data set switching via contact inputs will be active.
If *Data set selection* **414** is set to 1, 2, 3 or 4, the selected data set is activated and data set switching via the contact inputs is deactivated.
If *Data set selection* **414** is set to 5, data set switching will only take place if the frequency inverter is not enabled.

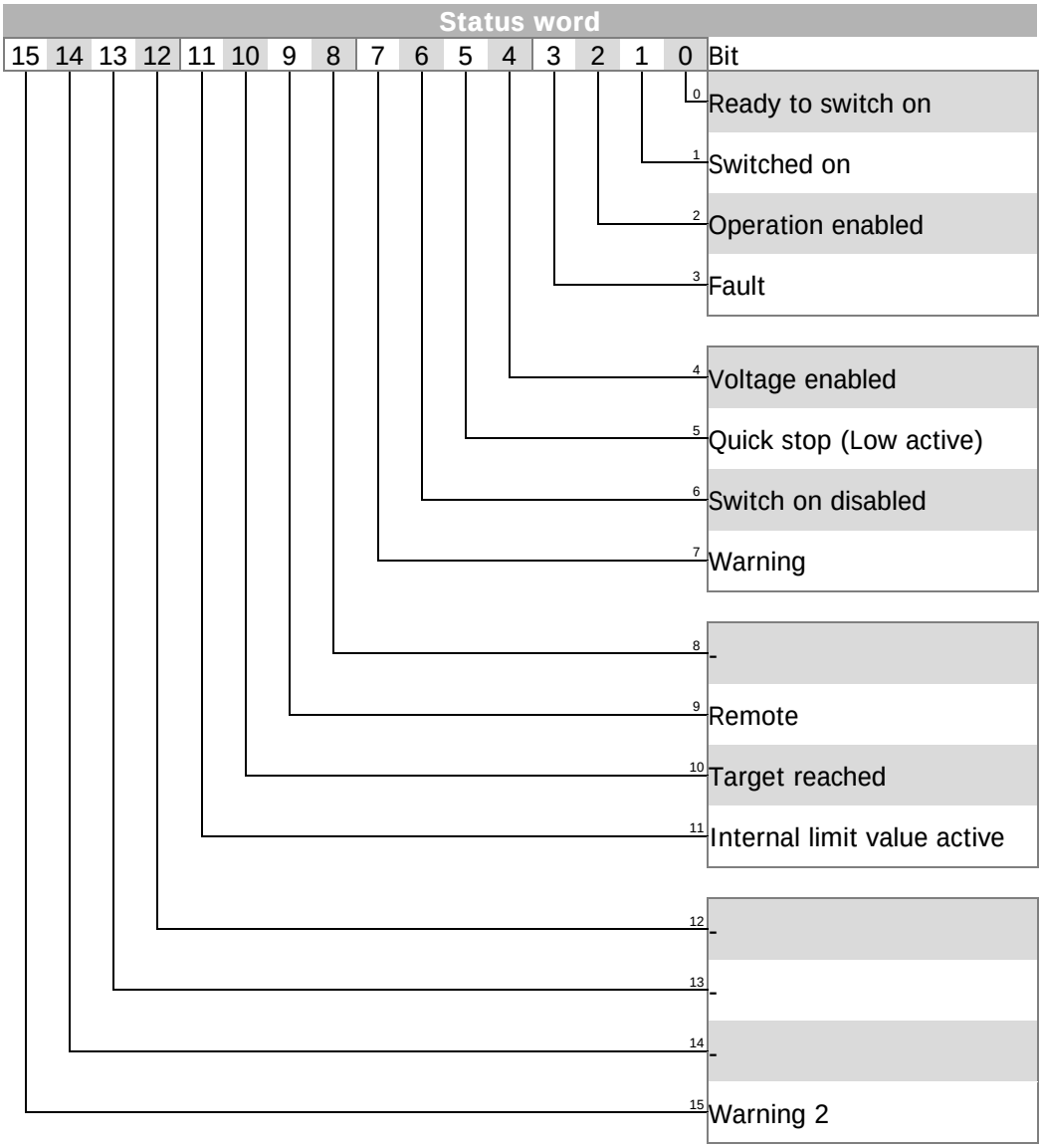
Via parameter *Active Data Set* **249**, the currently selected data set can be read. *Active Data Set* **249**, indicates the Active Data Set (value 1, 2, 3 or 4). This is independent of whether the data set switching was done via contact inputs or *Data set selection* **414**.

11.1 Control via contacts / remote contacts

In operation mode “Control via contacts” or “Control via remote contacts” (Parameter *Local/Remote* **412** = 0 or 2), the frequency inverter is controlled directly via digital inputs or via the individual bits of the virtual digital signals in the control word. The function of these inputs is described in the frequency inverter user manual.



The digital inputs set via the control word can be monitored using parameter *Digital Inputs* **250**. Digital input STOA and STOB will only be displayed if controller release is switched on at STOA and STOB **and** the control word (Bit 0) was set. If the data set switching function is used, please ensure that Parameter *Local/Remote* **412** is set to “2 – Control via remote contacts” is set in all data sets used.



If operation mode “Control via remote contacts” is used, controller release must be turned on at STOA (Terminal X11.3) and STOB (Terminal X13.3) **and** Bit 0 of the control word must be set in order to be able to start the drive.

The frequency inverters support an external 24 V power supply for the frequency inverter control electronics. Even when mains voltage is disconnected, communication between the controller (PLC) and the frequency inverter is still possible.

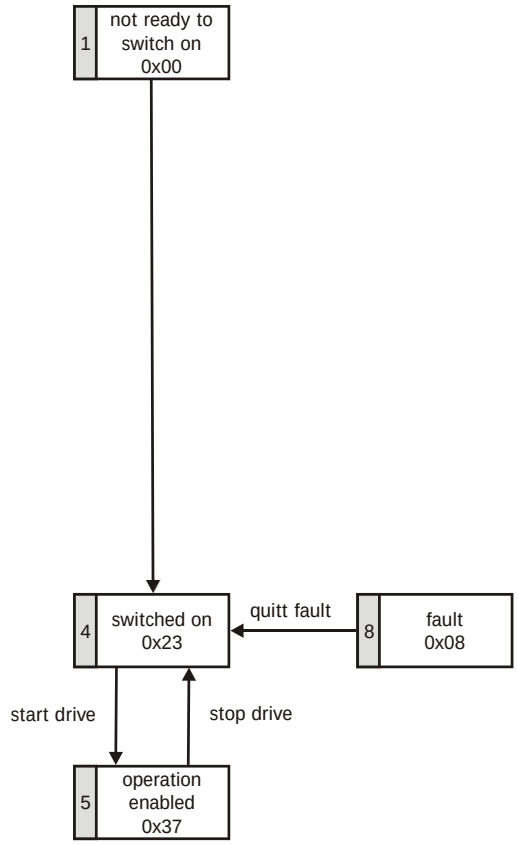
Bit 4 “Power supply – enabled” of the status word shows the current mains power supply status:

Bit 4 “Power supply – enabled” = **0** signals “No mains voltage”, starting of drive not possible.

Bit 4 “Power supply – enabled” = 1 signals “Mains voltage on”, drive ready for starting.

11.1.1 Device state machine

State machine:



Status word	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
Switched on	1	0	0	1	1
Operation enabled	1	0	1	1	1
Fault	x	1	x	x	x

"x" means any value.

Bit 7 "**Warning**" can display a device-internal warning message at any time. The current warning is evaluated by reading the warning status with parameter *Warnings* **270**.

Bit 10 "**Target reached**" is set when the specified reference value is reached. In the special case of power failure regulation, the bit is also set when the power failure regulation reaches the frequency 0 Hz (see frequency inverter Operating Instructions).
For "Target reached", there is a hysteresis (tolerance range) which can be set via the parameter *Max. control deviation* **549** see frequency inverter operating instructions).

Bit 11 "**Internal limit value active"** indicates that an internal limit is active. This may be the current limit, the torque limit or the overvoltage control. All functions will result in the reference value being left or not reached.

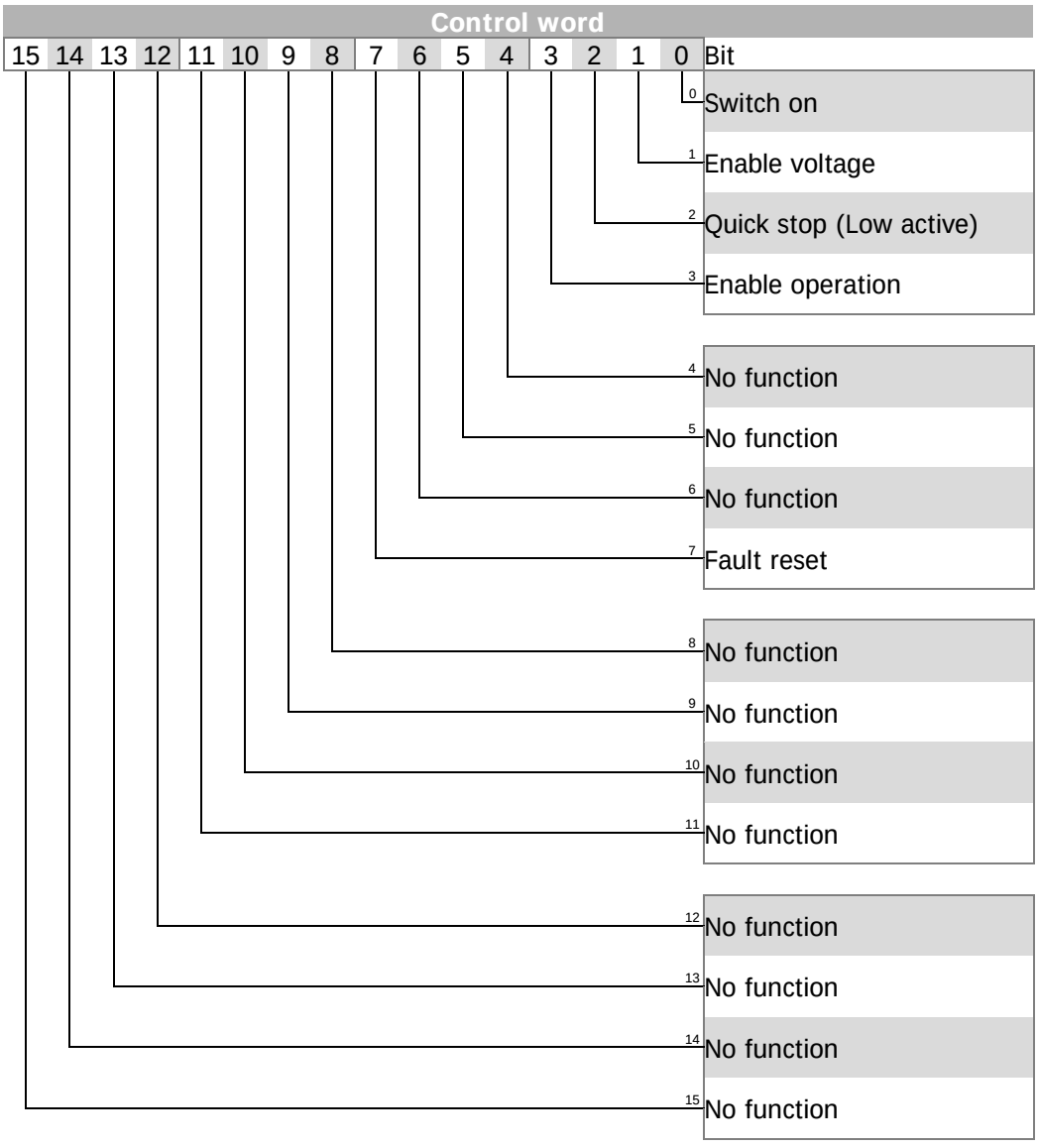
Bit 15 "**Warning 2**" signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

11.2 Control via state machine

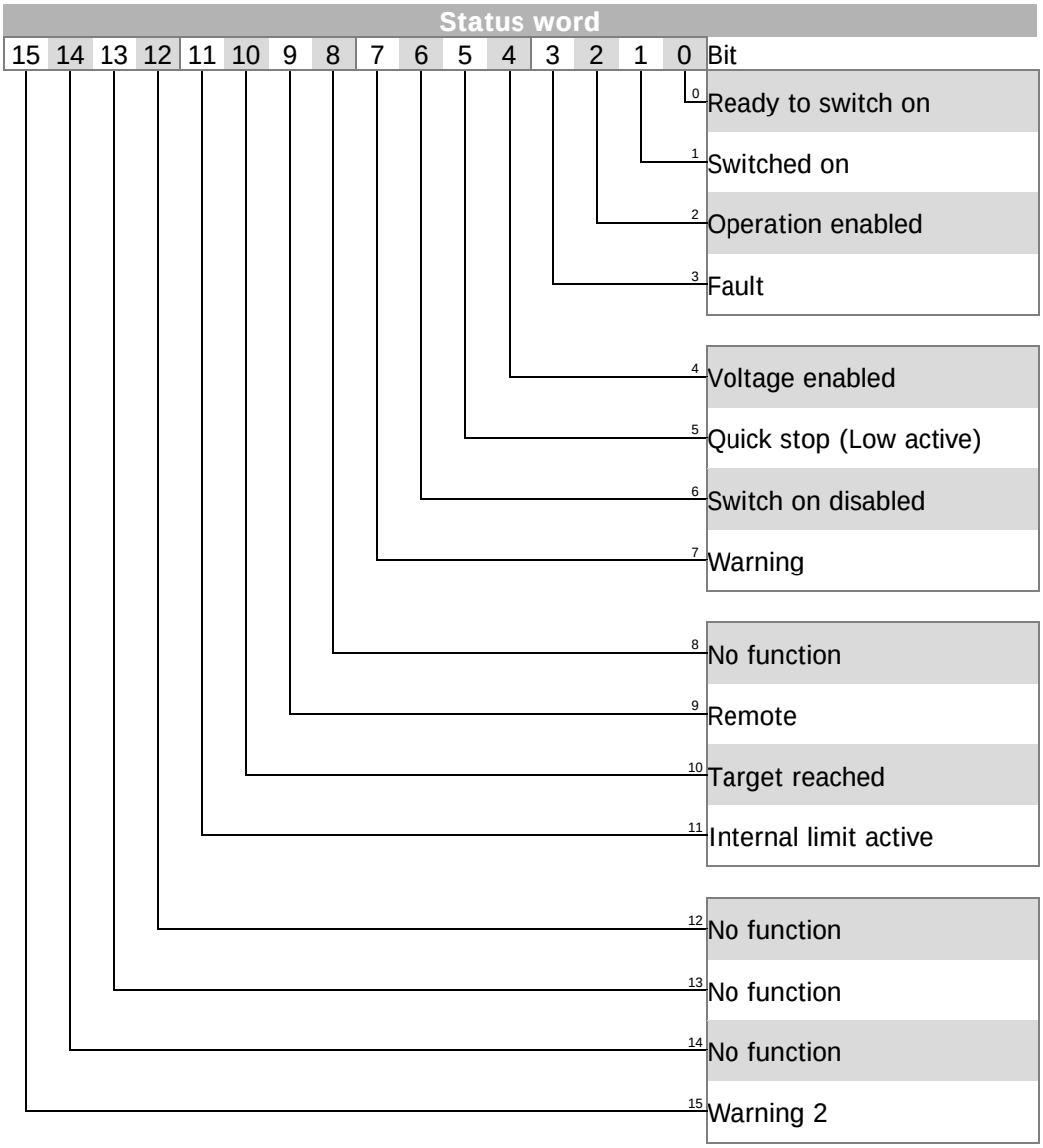
In this operation mode “Control via state machine” (*Local/Remote* **412** = 1), the frequency inverter is addressed via the control word of the state machine.

Transition 4 and 4’ to status “Operation enabled” is only possible if the release (STOA and STOB) and Start Clockwise or Start Anticlockwise are set.

Parameter *Control word* **410** is applicable to the frequency inverter if parameter *Local/Remote* **412** is set to “1 – Control via statemachine.



The actual value parameter *Status word* **411** shows the current operating status.



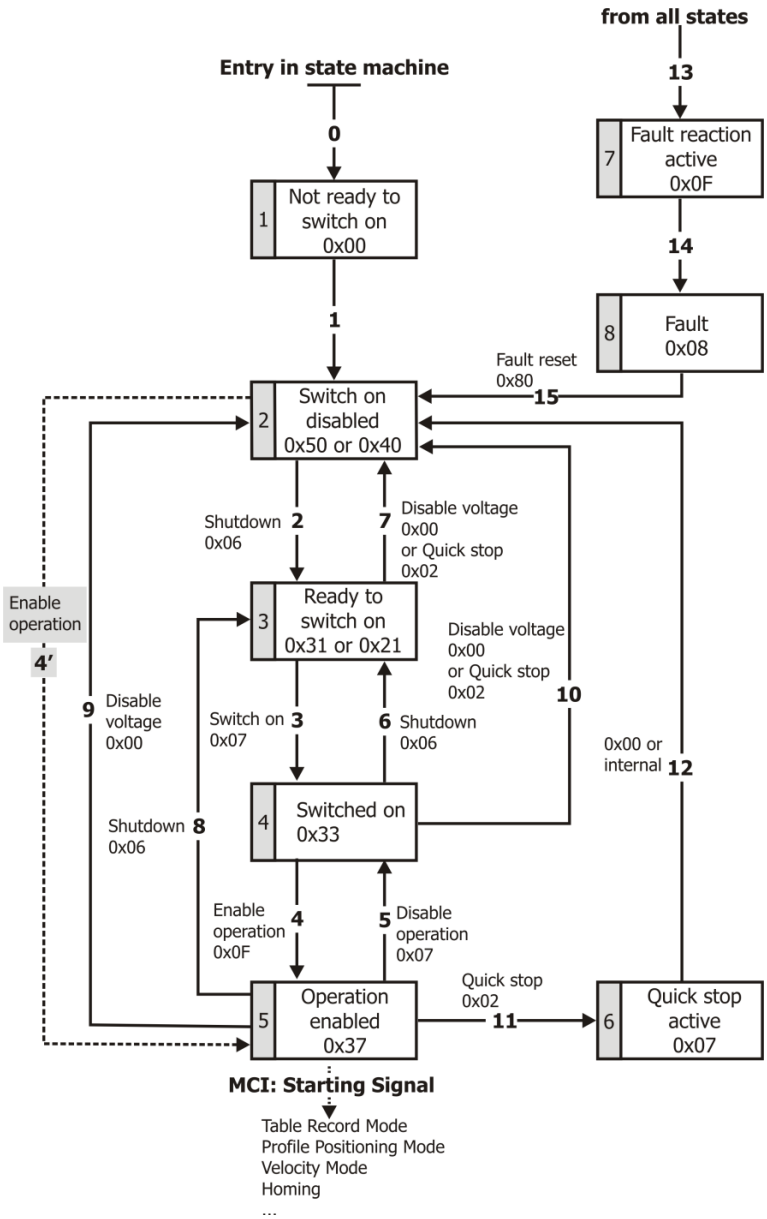
Agile frequency inverters support an external 24 V power supply for the inverter control electronics. Even when mains voltage is disconnected, communication between the controller (PLC) and the frequency inverter is still possible.

Bit 4 “Voltage enabled” of the status word shows the current mains power supply status:

Bit 4 “Voltage enabled” = **0** signals “No mains voltage”, starting of drive not possible.

Bit 4 “Voltage enabled” = **1** signals “Mains voltage on”, drive ready for start.

11.2.1 Statemachine diagram



Control word:
The device control commands are triggered by the following bit patterns in the status word.

Control word

Command	Bit 7 **Fault reset**	Bit 3 **Enable operation**	Bit 2 **Quick stop (Low active**	Bit 1 **Enable voltage**	Bit 0 **Switch on**	**Transitions**
Shutdown	X	X	**1**	**1**	**0**	2, 6, 8
Switch on	X	**0**	**1**	**1**	**1**	3
Enable operation	X	**1**	**1**	**1**	**1**	3
Disable voltage	X	X	X	0	X	7, 9, 10, 12
Quick stop (Low active)	X	X	**0**	**1**	X	7, 10, 11
Disable operation	X	**0**	**1**	**1**	**1**	5
Fault reset	**0 ⇨ 1**	x	x	x	x	15

"X" means any value.

Transition 3 (command “Switch On” [0x07]) will only be processed if Bit 4 “Voltage enabled” of the status word is set.

- Transition 4’ will only be processed if Bit 4 “Voltage enabled” of the status word is set.
- The frequency inverter can only be controlled if the logic operation is true. The logic inputs for Start Clockwise and Start Anticlockwise can be connected directly with “On” or “Off” (parameter *Start clockwise* **68** and *Start anticlockwise* **69**). Digital inputs (STOA and STOB) must be set.
  This results in:
  Release: = (STOA and STOB) **AND** (Start clockwise **OR** Start anticlockwise)

Status word:
The status word indicates the operating status.

Status word

State	Bit 6 **Switch on disabled**	Bit 5 **Quick stop (Low active)**	Bit 3 **Fault**	Bit 2 **Operation enabled**	Bit 1 **Switched on**	Bit 0 **Ready to switch on**
Switch on disabled	**1**	X	**0**	**0**	**0**	**0**
Ready to switch on	**0**	**1**	**0**	**0**	**0**	**1**
Switched on	**0**	**1**	**0**	**0**	**1**	**1**
Operation enabled	**0**	**1**	**0**	**1**	**1**	**1**
Quick stop active	**0**	**0**	**0**	**1**	**1**	**1**
Fault reaction active	**0**	X	**1**	**1**	**1**	**1**
Fault	**0**	X	**1**	**0**	**0**	**0**

“X” means any value.

Bit 7 **“Warning”** can be set at any time. It shows a device-internal warning.
The current warning can be read in the warning status with parameter *Warnings* **270**.

Bit 9 “**Remote”** is set if the operation mode is set to “Control via state machine” (*Local/Remote* **412** = 1) **and** controller release is turned on.

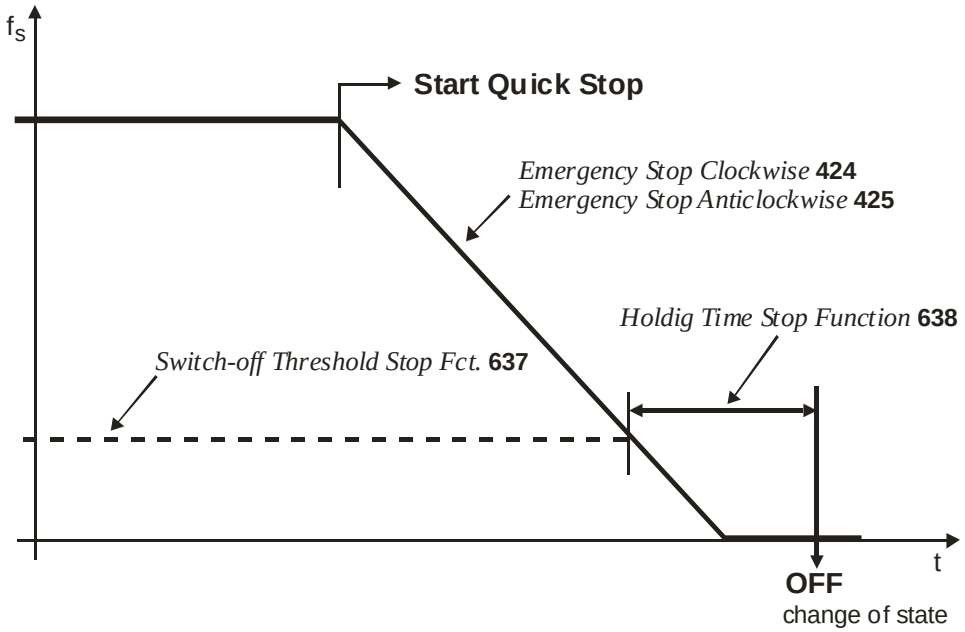
Bit 10 “**Target reached**” is set when the specified reference value is reached.
In configurations without Motion Control (parameter *Configuration* **30** ≠ x40) “Target reached” refers to the reference speed from OUT-PZD2. In the special case of power failure regulation, the bit is also set when the power failure regulation reaches the frequency 0 Hz (see frequency inverter operating instructions).
For "Target reached“, there is a hysteresis (tolerance range) which can be set via the parameter *Max. control deviation* **549** see frequency inverter Operating Instructions).

Bit 11 “**Internal limit value active”** indicates that an internal limit is active. This may be the current limit, the torque limit or the overvoltage control. All functions will result in the reference value being left or not reached.

Bit 15 “**Warning 2**” signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

11.3 Behavior in the case of a quick stop

In quick stop, the parameters *Switch-Off Threshold* **637** (percent of parameter *Maximum Frequency* **419**) and *Holding time* **638** (holding time after falling short of the Switch-Off Threshold) are relevant. *Maximum Frequency*. In the case of a quick stop, the drive is stopped via emergency stop ramps.
The emergency stop ramps are set via parameters *Emergency Stop Clockwise* **424** and *Emergency Stop Anticlockwise* **425** .



If frequency/speed reaches the value zero during the switch-off time, the drive continues to be supplied with current until the switch-off time has elapsed. This ensures that the drive is at a standstill when the state changes.

11.3.1 Behavior in the case of transition 5 (disable operation)

The behavior in transition 5 of the statemachine from “Operation enabled” to “Started” can be configured via parameter *State transition 5* **392**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
392	State transition 5	0	2	2

Operation mode	Function
0 - Coast to stop	Immediate transition from “Operation enabled” to “Switched On”, drive coasts to a standstill
1 - DC brake	Activation of DC brake, at the end of DC deceleration, there is the change from “Operation enabled” to “Switched On”
2 - Ramp	Transition with normal ramp, when the drive has come to a standstill, there is the change from “Operation enabled” to "Switched On"

Setting 1 “Direct current brake” is only possible with applications with U/f characteristic control (e.g. configuration 110). Other configurations do not support this operation mode.
If the frequency inverter is operated with a configuration which does not support the operation mode Direct Current Brake (e.g. configuration 210, field-oriented control), value "1" cannot be used.
In this case, the operation mode is not offered in the selection menus of the control unit KP500 and the control software VPlus.

By default, *State-transition 5* **392** is set to operation mode “2 - Ramp” For configurations with torque control, the default value is “0 - coast to stop”.
If the configuration is changed, the value set for *State-transition 5* **392** is also changed, if necessary.

If *State-transition 5* **392** was triggered with “1 - DC brake”, a new control word will only be accepted after completion of the transition process. The change of state from “Operation enabled” to “Started” is done after the *Braking time* **632** parameterized for the DC brake has elapsed.

If parameter *State-transition 5* **392** = “2 - Ramp” is set, the control word can be set to “Operation enabled” again, while the drive is decelerating. In this way, the drive accelerates to its set reference value again and remains in the state “operation enabled”.

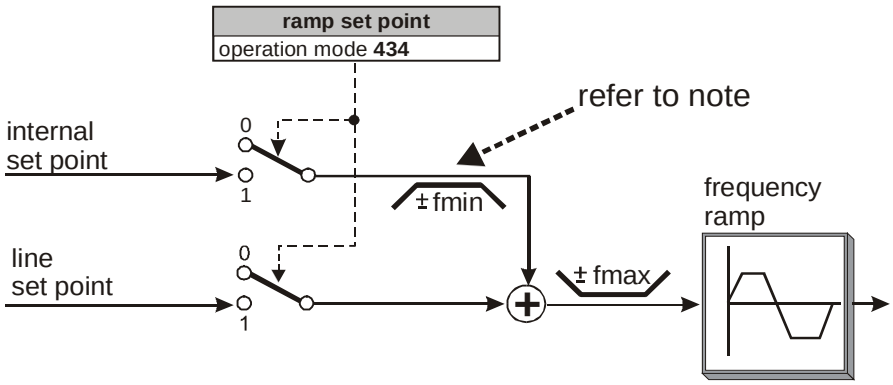
The change of state from “Operation enabled” to “Switched On” is done after the value has dropped below the set Switch-Off Threshold and the set holding time has elapsed (equivalent to the behavior in the case of a quick stop). In this context, parameters *Switch-Off Threshold stop function* **637** (percentage of parameter *Maximum Frequency* **419**) and *Holding time* **638** (Holding time after passing of threshold) are relevant.

11.3.2 Reference value / actual value

The controller (PLC) can set the reference frequency for the frequency inverter depending on the settings of Parameter *Reference frequency RAM* **484**, and receive the actual value via Parameter *Actual speed* **240**.

In the reference frequency channel, via parameter *Reference frequency source 1* **475** or *Reference frequency source 2* **492**, you can select setting “20 – Field bus reference value”.

The reference value for the frequency inverter from parameter *Reference frequency RAM* **484** is connected to the reference line value. This reference value will be combined with the internal reference value from the reference frequency channel and directed to the ramp. For information on the reference frequency channel, refer to the operating instructions of the frequency inverter.



The internal reference value from the reference frequency channel and the reference line value can be led to the ramp individually or as an added variable. The operation mode of the ramp function is set via the data set switchable parameter *Reference ramp* **434**.

Reference percentage **524** can be used for regular changing of reference percentages, e.g. as a reference value for technology controllers or a reference torque.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
434	Reference ramp	1	3	3
484	Reference frequency RAM [Hz]	-999.99	999.99	0.00
524	Reference percentage RAM [%]	-300.00	300.00	0.00

Operation mode 434	Function
1 - Internal reference frequency	The internal reference frequency is determined from the reference frequency channel.
2 - Reference line value	The reference value is supplied externally via the bus
3 - Internal reference frequency + reference line value	Addition (considering the sign) of internal reference frequency and reference line value

Actual values		
Parameters	**Contents**	**Format**
Internal Reference Frequency **228**	Total of reference value *Reference frequency source 1* **475** and *Reference frequency source2* **492**, see user manual of *Agile* frequency inverter.	xxx.xx Hz
Reference Bus Frequency **282**	Field Bus reference value from Field Bus	xxx.xx Hz
Reference Ramp Frequency **283**	Current reference frequency of ramp	xxx.xx Hz

11.3.3 Example sequence

One of the following sequences can be used:

1	Control word =	0x0000	Disable voltage
2	Control word =	0x0006	Shut down
3	Control word =	0x0007	Switch On
4	Control word =	0x000F	Enable operation

OR

1	Control word =	0x0000	Disable voltage
2	Control word =	0x000F	Enable operation

12 Actual values

Actual values		
No.	**Description**	**Function**
11	VABus SST error register	Modbus or VABus error register. See chapter 8.2.9 “Exception condition codes”.
282	Bus reference frequency	Reference value from serial interface / Modbus TCP.
283	Ramp reference frequency	Reference value from reference frequency channel.
411	Status word	Status word. See chapter 11.1 “Control via contacts/remote contacts”.

13 Parameter List

The parameter list is sorted numerically. For better overview, the parameters are marked with pictograms:

The parameter is available in the four data sets.

☑ The parameter value is set by the SET-UP routine

⊗ This parameter cannot be written when the frequency inverter is in operation.

13.1 Actual values (Menu “Actual”)

Actual value parameter				
No.	**Description**	**Unit**	**Indication range**	**Chapter**
RS485/RS232				
11	VABusSST-Error-Register	-	0 ... 15	8.2.9
Actual values of frequency inverter				
249	Active dataset	-	0 ... 4	11
260	Current error	-	0 ... 0xFFFF	14.5
270	Warnings	-	0 ... 0xFFFF	14.3
274	Warning application	-	0 ... 0xFFFF	14.4
282	Bus reference frequency	Hz	-999.99 ... 999.99	12
283	Ramp reference frequency	Hz	-999.99 ... 999.99	12
Bus control				
411	Status word	-	0 ... 0xFFFF	11.2
VABus/TCP				
1431	Module Info		String	VABus/TCP manual

Parameters *Current error* **260,** *Warnings* **270** and *Application warnings* **274** are only accessible via Field Bus. They cannot be addressed via the VPlus control software or the control unit.

13.2 Parameters (Menu “Para”)

Parameters				
No.	**Description**	**Unit**	**Setting range**	**Chapter**
Modbus/TCP				
388	Bus Error Behaviour	-	0 ... 5	7.3
Bus control				
392	State Transition 5	-	Selection	11.3.1
410	Control word	-	0 ... 0xFFFF	11.2
412	Local/Remote	-	Selection	11
Data set switching				
414	Data set selection	-	0 ... 4	11
Frequency ramps				
434	Ramp setpoint	-	Selection	11.3.2

Fixed frequency values				
No.	**Description**	**Unit**	**Setting range**	**Chapter**
484	Reference frequency RAM	Hz	-999.99 ... 999.99	11.3.2
Fixed percentages				
524	Reference percentage RAM	%	-300,00 ... 300.00	11.3.2
Modbus/TCP				
1432	IP Address	-	-	7.2
1433	Netmask	-	-	7.2
1434	Gateway	-	-	7.2
1435	DNS Server	-	-	7.2
1436	DHCP Option	-	Selection	7.2
1437	IP command	-	Selection	7.2
1439	Modbus/TCP Timeout	ms	0 ... 60000	7.2.3
1440	Email Function	-	Selection	7.2
1441	Email Text (Body)	-	Text	7.2

14 Appendix

14.1 List of control words

The following table provides an overview of the functions of the **control word** bits if Control via state machine (*Local/Remote* **412** = "1 - Control via statemachine").

Bit	*AGL Control word*
0	Switch On
1	Enable Voltage
2	Quick Stop (low active)
3	Enable Operation
4	
5	
6	
7	Fault reset
8	
9	
10	
11	
12	
13	
14	
15	

14.2 Overview of status words

The following table provides an overview of the functions of the **status word** bits if Control via state machine (*Local/Remote* **412** = "1 - Control via statemachine").

Bit	*AGL Status word*
0	Ready to Switch On
1	Switched On
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick Stop (low active)
6	Switch On Disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	
13	
14	
15	Warning 2

14.3 Warning messages

The different control methods and the hardware of the frequency inverter include functions for continuous monitoring of the application. In addition to the messages documented in the frequency inverter user manual, further warning messages are activated by the Field Bus communication The bit-coded warning reports are issued via parameter *Warnings* **270** according to the following pattern:
Parameter *Warnings* **269** indicates the warnings as plain text in the control panel and the VPlus PC control software.
Use parameter *Warnings* **270** in order to read the warning messages via Field Bus.

Warning messages		
Bit no.	**Warning code**	**Description**
0	0x0001	Warning Ixt
1	0x0002	Warning short-time Ixt
2	0x0004	Warning long-time Ixt
3	0x0008	Warning heat sink temperature Tk
4	0x0010	Warning inside temperature Ti
5	0x0020	Warning Limit
6	0x0040	Warning Init
7	0x0080	Motor temperature warning
8	0x0100	Warning mains failure
9	0x0200	Warning motor circuit breaker
10	0x0400	Warning Fmax
11	0x0800	Warning analog input MFI1A
12	0x1000	Warning analog input MFI2A
13	0x2000	Warning Systembus
14	0x4000	Warning Udc
15	0x8000	Warning *Application warnings* **273**

The meanings of the individual warnings are described in detail in the frequency inverter Operating Instructions.

14.4 Application warning messages

When the highest bit of the warning message is set, an “Application warning message” is present. The application warning messages are bit-encoded as per the following pattern via parameter *Application warnings* **274.** Parameter *Application warnings* **273** indicates the warnings as plain text in the control panel and the VPlus PC control software.
Use parameter *Application warnings* **274** in order to read the warning messages via Field Bus.

Application warning messages			
Bit no.	**Warning code**	**Description**	
0	0x0001	BELT	- V-belt
1	0x0002	(reserved)	
2	0x0004	(reserved)	
3	0x0008	(reserved)	
4	0x0010	(reserved)	
5	0x0020	(reserved)	
6	0x0040	SERVICE	– Service Warning
7	0x0080	User 1	– User Warning 1
8	0x0100	User 2	– User Warning 2
9	0x0200	(reserved)	
10	0x0400	(reserved)	
11	0x0800	(reserved)	
12	0x1000	(reserved)	
13	0x2000	(reserved)	
14	0x4000	(reserved)	
15	0x8000	(reserved)	

For details on the warnings, refer to the frequency inverter Operating Instructions.

14.5 Error messages

The error code stored following a fault comprises the error group FXX (high-byte, hexadecimal) and the code YY (low-byte, hexadecimal).

Communication error		
Key		**Meaning**
F27	14	Communication loss to PLC

The current error can be read via parameter *Current error* **260**.
Parameter *Current error* **259** indicates the current error as plain text in the control panel and the VPlus PC control software.
In addition to the errors listed, there are other error messages. However, they are used for internal purposes only and are not listed here. If you come across fault messages which are not listed here, please do not hesitate to call us.

14.6 Conversions

The speeds/frequencies can be converted to other speed formats using the formulas in this chapter:

Frequency [Hz] into	speed [1/min]	See Chapter 14.6.2
Speed [1/min] in	Frequency [Hz]	See Chapter 14.6.1

14.6.1 Speed [1/min] into frequency [Hz]

$$f\ [\mathrm{Hz}] = \frac{n[\mathrm{min}^{-1}] \times No.of\ pole\ pairs\ \ (P.373)}{60}$$

14.6.2 Frequency [Hz] into speed [1/min]

$$n[rpm] = \frac{f\ [\mathrm{Hz}] \times 60}{No.of\ pole\ pairs\ (P.373)}$$

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